

CERTAIN ASPECTS OF PLANETARY JOINTING AND RELATED
PHENOMENA

S.S. Shul'ts

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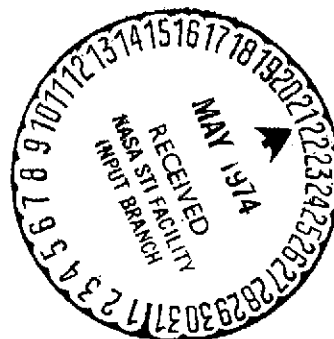
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16. Abstract Planetary jointing is defined as endokinetic joints whose dimensional orientation is not related to local features, but to general planetary ones (Figure 1). The vector diagrams of jointing for vast, separate and geologically different areas of the Russian platform were constructed in the laboratory. The orientation of joint systems in these diagrams corresponds to the theoretical planetary stress network depending on rotational forces at the present position of the Earth's poles. The diagrams for limited regions differ greatly. The correlation of these diagrams with the age and composition of the rocks, geological structure and location is noted.			
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S. S. Shul'ts

The planetary network of joints separates the Earth's crust and rocks, its constituents, into blocks of various size. It is the basis on which the tectonic structure and forms of surface relief of the Earth are developed. 186*

Analysis of planetary jointing affords the possibility of restating many problems of the development of the Earth structure in time and space and of taking a new approach to structural geomorphology, which determines the basic laws of structure of Earth's contemporary surface. At the same time the solution of this problem may yield practical results in the search for local structural forms in closed regions.

The Planetary Jointing Laboratory of the Leningrad University is investigating the planetary jointing of various scales and associated lineaments in their various manifestations in relief and landscape.

1. Planetary joints are defined as those whose spatial orientation is related not to local but to general planetary phenomena. Planetary joints are distributed universally. They cut across sedimentary, metamorphic and igneous rocks and are developed both in folded regions and in regions of horizontal deposition of rocks. The scale of planetary joints may vary from deep faults to joints found only with an individual strata.

The Leningrad State University Planetary Jointing Laboratory began its studies with depositions of the sedimentary mantle of the Russian platform, since we feel that analysis of general jointing in horizontal or slightly fractured sedimentary depositions may yield simpler and more understandable materials for subsequent derivations. Here the rock strata are divided universally by two (or more) systems of nearly vertical joints, oriented in some way in space¹. They do not intersect each other in vertical cross-sections. On 187

*Numbers in the margin indicate pagination in the foreign text.

¹A system is defined as a natural group of joints with similar strike azimuth. Systems usually form related pairs with angles between systems close.

the other hand the examined joint systems do intersect in horizontal section. Consequently the joints divide the rocks into parallelepiped blocks (Figure 1).

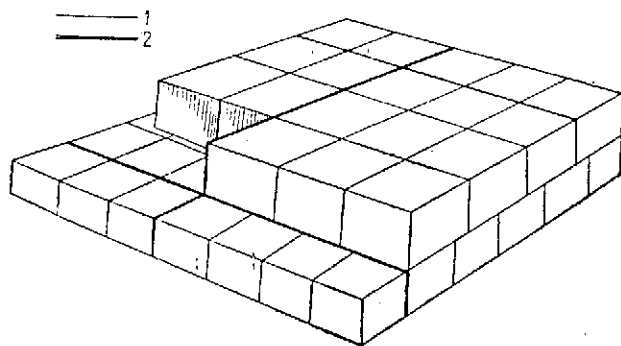


Figure 1. Block Diagram of Planetary Jointing in Horizontal Strata:

1, Second-order joints and stratification boundaries; 2, First-order joints.

There are, in addition to intrastratal joints, the thickness of which is functionally related to the thickness of the strata, rarer and larger joints in outcroppings and excavations, intersecting several strata and usually extending beyond the boundaries of the examined outcroppings. Thus blocks of various size are formed, inscribed in each other, since joints of different order form the same systems, oriented in a certain way relative to the geographic meridian.

We, like certain other investigators, attribute the origin of the examined jointing in the horizontal sedimentary rocks of the platform to intensive internal stresses experienced by the strata and seams of depositions during their transformation from sediment to rock — their lithification and subsequent diagenetic changes.

It is quite obvious that internal factors governing the origin of the described general jointing cannot in themselves explain the regular orientation of the systems of examined joints relative to the points of the compass.

All available data indicate that explanation of sustained strikes of the examined jointing systems, characterized by certain azimuth, can be found only in some general planetary causes. Apparently, the magnitude of stresses that result in orientation of planetary jointing need not be especially great. Proposed general factors operate periodically as a "lowering hook." These external factors govern only the orientation of the jointing systems relative to the meridian, and consequently relative to the axis of rotation of the planet, regardless of their lithogenetic jointing.

Many investigators directly or indirectly connect the orientation of planetary jointing systems with rotational factors, with changes of the angular velocity of the Earth. Some feel that the position of the axis of rotation was constant or nearly constant and others explain the variability of strike of the joints to displacement of the poles by continental drift or movement of individual blocks, intrusions in the crust, convection currents in the Earth's mantle, etc. /88

2. Some geologists contend that jointing of the described type and by its formation and orientation in space, is the result of tectonic dislocations.

Sometimes the joints in sedimentary formations of the platform are related to vertical movements of blocks of the crystalline foundation. It is completely impossible, however, to imagine that radial displacements of foundation blocks, shifting through thick layers of blocks of variable composition, generate and regularly orient joints of the above-described type, including intrastratal joints, which by their frequency, are related not to the size of the block, but to the thickness of the given stratum. Moreover, such interpretation explains nothing, but simply shifts the question of joint origin from the platform mantle to the foundation.

Both the formation and orientation of the examined joints are also attributed to "pressure" exerted on the platform by mobile regions. Such explanation, it seems to us, is even less probable than the preceding. Actually, it is difficult to admit that tangential tectonic "pressures," for example "pressures" from the mural and grampian geosynclines, transmitted for thousands of kilometers, should produce oriented joint systems in horizontal rocks. Meanwhile, such explanations are still being given in works on Estonia and the Leningrad region.

The theories that attribute the examined jointing to local platform structural forms are considerably more interesting. Such relations were most thoroughly described by Ye. N. Permyakov (1949). Ye. N. Permyakov established empirically the rule according to which the diagonal of a parallelogram, constructed on diagonal² rays of the rose diagrams of joints developed in a given region, extends along the strike line of the axis of the structure. The

²Ye. N. Permyakov calls joints, directed in the appropriate manner relative to the axis of the structure, "diagonal" and "longitudinal" rays (and types).

relation between the length of the main diagonal rays and the angle between them makes it possible to determine several structural features of brachy-anticlines. However, in order to know which rays are diagonal and which is the axis of the parallelogram constructed on them, corresponding to the axis of folding, it is first necessary to know its strike.

During the expedition of the laboratory of Leningrad State University in the Volga Valley, where Ye. N. Permyakov did his investigations, we measured joints and constructed rose diagrams on already known ones with structural charts and small local uplifts. To determine the strike of local uplifts R. I. Bayeva proposed instead of constructing a parallelogram and drawing diagonals, simply to connect the ends of the main "diagonal" rays or ends of the vectors in the diagrams with a straight line. When the vectors are used, this simplifies and also refines the solution of the problem. Regardless of what method is used, however, we will see that the relation between jointing and /89 the strike of structural forms of platform appears differently.

R. I. Bayeva (1968) described three cases of such interrelations for the middle Volga Valley. In one case (Sokolovogorskoye uplift) fold axis is almost parallel to the line connecting the northwest and northeast ends of the vectors and the axis of the parallelogram, with strikes close to latitudinal. In another case (Zhirnovskoye uplift) the fold axis is parallel to the line connecting the northwest and southwest ends of the vectors and the other axis of the parallelogram is nearly meridional. In the third case, finally, (Teplovskoye uplift) the parallelogram rule does not apply and the fold axis nearly coincides with one (northwest in the given case) of the joint systems. Thus, the strike of the fold axes changes. It is close to latitudinal in the Sokolovogorskoye uplift, meridional in the Zhirnovskoye uplift and northwest in the Teplovskoye uplift. However, the strike of the joint systems is very similar in all cases — northeast and northwest.

A whole series of observations, like the above examples, indicate the existence of certain relations between the strike of jointing and platform structures. This does not mean, however, that we agree with Ye. N. Permyakov that the examined jointing is connected with "warping of strata during

epeirogenesis and formation and growth of tectonic structures under the influence of radial uplifting forces." [1].

It seems to us that the cited examples become clearer if we consider not only that jointing may be fundamentally related to uplifts but also, on the other hand, that extremely flat local platform structures are adapted in some way to the primary planetary jointing network. For the middle Volga Valley it is characterized basically by a type which is diagonal relative to the geographic meridian.

Two vectors, northeast 42° (49%) and northwest 315° (51%) (Figure 2, a), are distinctly seen in the summary rose diagram of jointing of all measurements conducted by the Leningrad State University expedition in the middle Volga Valley. About the same vectors (northeast 44 and northwest 315°) can also be traced in the summary diagram of measurements taken by the expedition to the northwest Russian platform (Figure 2, b).³ Meanwhile, this region is not only quite remote from the middle Volga Valley, but it is also made up of different rocks. The same vectors of strike of the main diagonal joint systems can also be seen on the summary diagram for the Russian platform (43 and 315°) according to the data of the Leningrad State University expedition and (45 and 318°) according to Ye. N. Permyakov's data (Figure 2, c, d).

G. N. Catterfeld and G. V. Charushin characterize the summary diagram of strike of the Russian platform jointing, which they constructed on the basis of 35,900 measurements, by the rays: 45 , 85 , 325 and 355° . The same investigators give for the southern part of the Siberian platform (25,000 measurements) the rays 44 , 274 , 314 and 355° . For the northeastern part of the Siberian platform A. F. Grachev and I. P. Fedorov trace two vectors, 44 and 320° (on the basis of measurements of 40,000 joints made by co-workers of the Institute of Arctic Geology). N. V. Shablinskaya, for the southern part of Western Siberia, constructs the summary rose with rays 45 and 312° (3,387 measurements).

³The secondary vector of meridional direction as it appears here is discussed later.

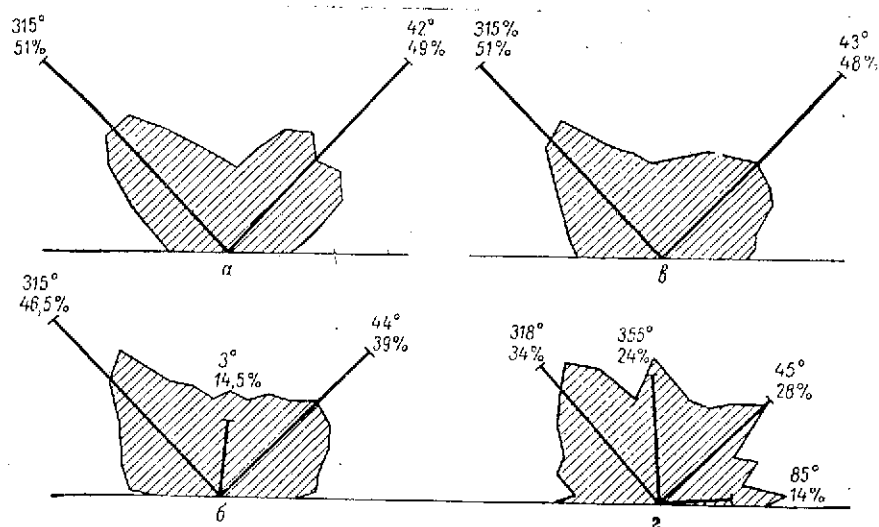


Figure 2. Summary Rose Diagrams and Vector Diagrams of Planetary Joints: a, Middle Volga Valley (5,840 measurements); b, Northwest Russian platform (23,161 measurements); c, Russian platform according to data of the LSU expedition (29,005 measurements); d, Russian platform according to Ye. N. Permyakov's data (19,607 measurements).

Thus, the summary diagrams of strike of joints constructed for much of the territory on the basis of many measurements, show 2, 3, or 4 joint systems, and in all cases 2 of them are present — the northeast and northwest. In these examples the azimuth of strike of the first system varies from 42-45° and of the second from 312-325°.

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Such similarity of strike of the basic diagonals of the jointing systems in vast and distant regions, of different outline and made up of rocks of different age, and revealed as the result of statistical processing of illuminous data, as proof of the generality that factors which cause orientation of the examined joints are planetary in nature.

While the summary data on jointing of large regions statistically yield very similar strikes for the basic jointing systems, the measurements of joints in individual outcroppings, quarries and small regions differ from each other. The strikes of the rays and rose vectors constructed on the basis of different walls or different stages of a given cut, usually vary from 10-25° (up to 45° in individual cases). The various rays may turn all together or individually,

accompanied by a change of angle between them; the relative length of the vectors may also change. Sometimes new rays appear instead of the 2 predominant rays. Other times the entire character of the roses changes.

In the case of absolutely horizontal deposition the roses are usually the simplest and most distinct (Figure 3). In the case of local dislocations (small folding, for example, observed in Ordovician limestones at the southern end of the Koporskaya uplands), partial and summary jointing roses become complex multi-ray diagrams (Figure 4). No one has been able to ascertain the relationship between the variability of the roses and the exposure of the walls of quarries or cuts. Apparently the measurement method, number of measured joints (we require 50 to 100) and simply the individual features of the investigator conducting the measurement, are of considerable importance. /92

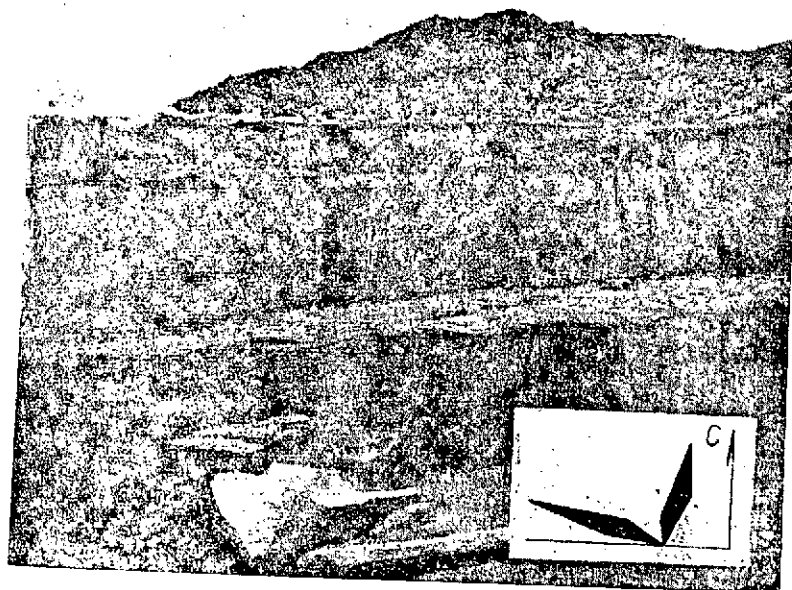


Figure 3. Jointing in Horizontal Devonian Limestones in Staro-Izborsk Quarry and Rose Diagram. Photograph by S. S. Shul'ts.

Basically, however, the variation in character and azimuth of strike of joints which we investigated is related, in our opinion, to the effect on jointing of rocks not only of the single general planetary factor, but also to other factors, which we are not yet able to take into consideration. It may influence the local change of strike or appearance of joints in new directions.



Figure 4. Jointing in Deformed Ordovician Limestones in Vrud Quarry and Rose Diagram. Photograph by G. A. Putintseva.

When the summary jointing roses of several exposures for the summary roses of maps on the scale 1:100,000 are compared, the difference in the azimuths of the rays and vectors of the diagrams lessens and rarely exceeds 15° (maximum of $20-25^\circ$), and between larger regions (region of the Koporskaya uplands; northern Estonia, etc.), it usually does not exceed 10° .

Thus, the greater the area of observation (and accordingly the greater the number of measurements), the less the magnitude of deviations of the average azimuths of strike of jointing systems.

The summary rose diagram for large regions (within more or less tectonically uniform zones) may be taken as the regional background of planetary jointing. Problems of global change of the background of planetary jointing and analysis of anomalies of the background are future tasks of the laboratory.

We endeavored to find out if there are any laws in the change of strike of jointing within regions. The problem was stated as follows: do rocks of different age have different jointing systems? We conducted measurements of jointing in the middle Volga Valley in Lower Carboniferous, Lower and Upper Cretaceous, Paleogenic and Quaternary formations. The data presented in Table 1 show that the jointing systems in rocks of different ages differs

somewhat. In addition, two main rays, comparable to each other, are clearly seen. Comparing their position, we see that the azimuths of strike of the younger bedrocks of the Volga Valley are rotated somewhat clockwise relative to the older formations (Quaternary formations are peculiar). However, our conclusion was not verified by studies on the northwestern Russian platform (Table 2). Curiously, the Quaternary formations in both regions have similar strike azimuths in the diagrams.

TABLE 1. STRIKES OF JOINTING OF ROCKS OF DIFFERENT AGE IN MIDDLE VOLGA VALLEY
(THE FRACTION OF THE TOTAL NUMBER OF MEASUREMENTS IS ENCLOSED IN PARENTHESES, AS IN TABLE 2)

Age of Rock	Azimuth of Strike of Jointing Systems in Degrees				No. of Measurements
	Main Rays		Secondary Rays		
	NE	NW	Meridional And Close To It	Latitudinal And Close To It	
Carboniferous	37 (49)	312 (51)	-	-	3075
Lower Cretaceous	63 (33)	320 (35)	21 (32)	-	453
Upper Cretaceous	68 (36)	340 (32)	13 (13)	290 (19)	1640
Paleogenic	-	345 (62)	-	88 (37)	195
Quaternary	46 (55)	323 (45)	-	-	147

TABLE 2. JOINTING STRIKES OF ROCKS OF DIFFERENT AGE IN NORTHWESTERN RUSSIAN PLATFORM

Age of Rock	Azimuth of Strike of Jointing Systems in Degrees				No. of Measurements
	Main Rays		Secondary Rays		
	NE	NW	Meridional And Close To It	Latitudinal And Close To It	
Cambrian	48 (37)	324 (29)	4 (18)	279 (16)	850
Ordovision	49 (39.5)	316 (46)	3 (14.5)	-	11627
Devonian	47 (23)	320 (36)	7 (22)	275 (18)	5295
Permian	54 (48)	314 (51)	-	-	2300
Quaternary	43 (46)	325 (44)	-	-	1950

For comparison of the variability of the jointing plan in space the effective age must be excluded. We analyzed the seam of ordovision limestones, extending in strike for a distance of more than 500 km across Northern Estonia and into the Leningrad Oblast'. 11,627 joints were measured along this formation. Analysis of the assembled material is not yet complete and we can report only on preliminary data.

Three strikes are distinguished here for the ordovision: northeast 49° , northwest 316° and north 3° . In individual parts of the ordovision formation, however, the azimuths of the main, diagonal rays differ somewhat. For Estonia they are 42° and 318° , and for Leningrad Oblast' they are 57° and 323° (Table 3).

TABLE 3. CHANGE OF STRIKE OF VECTORS IN JOINTING DIAGRAMS ALONG ORDOVISION OUTCROPPINGS OF NORTHERN ESTONIA AND LENINGRAD OBLAST'

Northern Estonia		Leningrad Oblast'	
$42^\circ \ 318^\circ$		$57^\circ \ 323^\circ$	
West $41^\circ, \ 313^\circ$	East $44^\circ, \ 324^\circ$	West $45^\circ, \ 325^\circ$	East $31^\circ, \ 314^\circ$

Comparing the strikes of the joints in Leningrad Oblast' and in Northern Estonia, we see that the azimuths of both rays increase from west to east and the rays rotate clockwise. The same is true of Eastern and Western Estonia. In Leningrad Oblast', however, comparison with the region to the west of Leningrad (Koporskaya Uplands) and the region to the east of Leningrad (to Volkhov) reveals the opposite pattern. The strike azimuths of both main rays diminish from west to east and the rays turn counter-clockwise. The main diagonal rays turn clockwise on both sides as they approach the boundary of Leningrad Oblast' and Estonia (region of the City of Narva). In the Narva area we see the orthogonal type of jointing with well-expressed meridional rays.

Thus, in addition to tracing gradual changes of strike of diagonal jointing of the ordovision in the latitudinal direction (with strike), we see an intersecting band of the ordovision, transverse to the zone that divides the investigated region into two parts. The orthogonal and four-ray roses are observed

here in many cuts along the meridional zone, extending toward Narva, and also on both banks of the Narva River. This zone extends further to the south along the Narva River and Velikoye and Pskovskoye Lakes. We cut into it to study the jointing in the Devonian in the vicinity of Pskov and Stariye Izborsk. Orthogonal jointing systems are also developed here. Sometimes, at a cut near Stariye Izborsk, for example, we see only distinct orthogonal joints, and nothing else (see Figure 3), whereas in the cut near the City of Pskov, in horizontal limestones, jointing is characterized by a multi-ray diagram. Exposed in this cut is a band of limestones, within which, in addition to the usual vertical joints, are also seen distinct inclined joints, intersecting each other not in plan, but on the walls of the cut. The joints extend toward the northeast or northwest at angles of 45 to 70° with a strike close to northwest 340°. These are typical joints of the Moor (Figure 5).

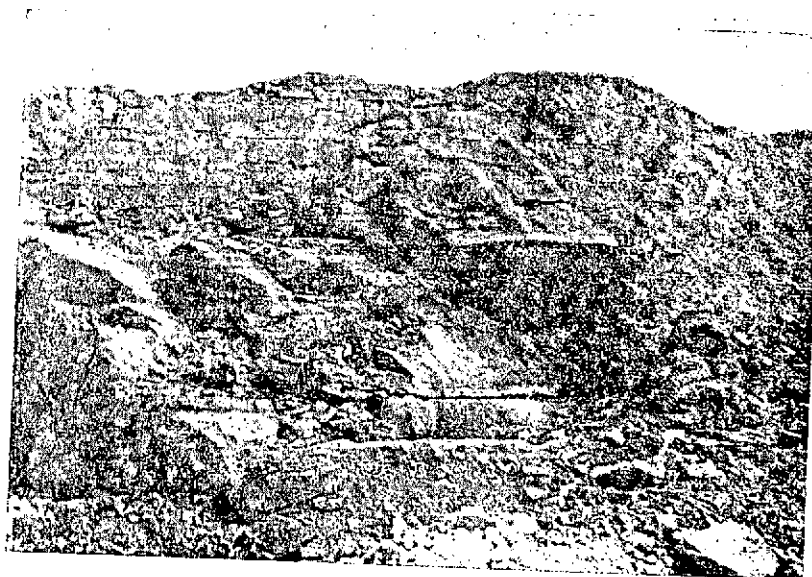


Figure 5. Diagonal Joints in Devonian Limestones in Cut Near Pskov. Photograph by S. S. Shul'ts.

Hatching and small faults, with the southwest wings subsided, were also observed in some cases along the inclined joints. We also observed small displacements (faults and right dislocations) along vertical joints. Traces of shifts in the seam of limestones and appearance within it of more joints, quite unusual for the described region, indicate the presence here of tectonic dislocations. They are apparently related to the above-mentioned meridional

zone. Inherent to the same zone are Gdov dislocations and other tectonic faults. It has been noted by many investigators on the basis of general geologic, structural and geophysical analyses. The meridional zone, extending from Narva to Pskov, is well exemplified in the relief of the northwest Russian platform and may be viewed as a vast lineament.

All the features of the examined area are apparently related to the orthogonal planetary jointing system that predominates within it.

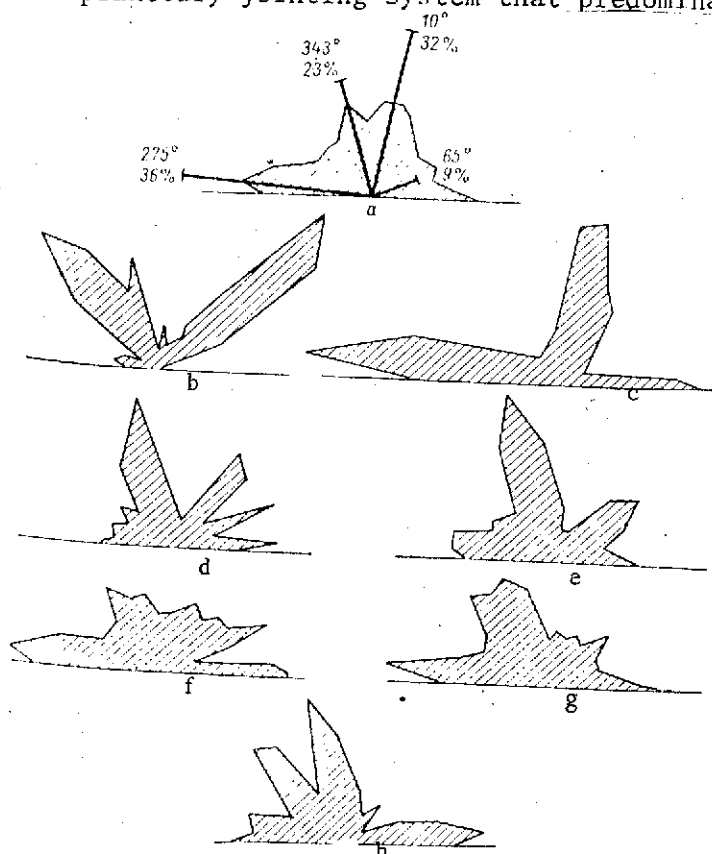


Figure 6. Summary of Roses and Vector Diagrams: a, Planetary joints of southeastern extremity of Baltic Plate; b-g, Rose diagrams of jointing of rocks of various composition and age of southeastern extremity of Baltic Plate: b, Stratified formations of the Archean and Lower Proterozoic; c, Iotniyskiy quartz sandstones of Petrozavodsk Region; d, Gabbro diabbases (Pt₃) of Petrozavodsk Region; e, Vyborgsk Rapakivi granites (Pt₃); f, Pitkyarantinskiy Rapakivi granites (Pt₃); g, Microclinitic granites of northwest shores of Ladozhskoye Lake (Pt₃); h, Microclinitic granites of northern shores of Ladozhskoye Lake (Pt₁₋₂).

The laboratory undertook /95 investigations of jointing along the periphery of the Baltic Plate — on the Karelian Isthmus and in Karelia. At this time we can only report on the most general data.

The origin of the joints in igneous and metamorphic rocks, as in sedimentary, are related basically to endogenic processes (in this case chiefly to cooling, crystallization, etc.). According to our theories, planetary phenomena are here also very important in the principles of three-dimensional orientation of jointing systems. On the basis of the rose diagram constructed on the basis of all processed measurements, conducted by the LSU expedition at the southeastern extremity of the Baltic Plate, there are four vectors with the following

strike azimuths: 10° (32%), 65° (9%), 275° (36%) and 343° (23%) (Figure 6). The four vectors on the diagram are combined into pairs with angles close to 90° in each pair. Comparing the examined jointing rose of the Baltic type with /96 quite similar jointing roses of the Russian platform as a whole or of individual large regions of it (Figure 2), we see substantial differences. The orthogonal rays in this case are much better developed than the diagonal. The vectors on the summary diagram of the Baltic Plate are rotated relative to the corresponding vectors on the diagram of the Russian platform (See Figure, d) by + [illegible], +20, +10 and +25°. Although the angle of rotation is significant, particularly for [illegible] vector, all vectors nevertheless turn in the same direction, clockwise.

If we compare the rose diagram of the jointings of the southeast periphery of the Baltic Plate (Figure 6, a) with the rose diagram of jointings of the southwest periphery of the Plate (see Figure 7, b) then in this case too we see rotations by +11, +3, +9 and +16° clockwise. Thus the jointing systems of the Plate in Southern Norway are closer in strike to the joints of the Russian Plate (rotated by +4, +17, +1 and +9°) than to those in Southern Karelia, and the latter than to the joints of the Russian platform. All of this suggests that the differences in the examined rose of diagram of the southeastern edge of the Baltic Plate, though significant, nevertheless say nothing of the fundamental features of jointing of the Plate or of any general factors other than on the Plate, producing the three-dimensional orientation of planetary jointing.

A certain relationship is noted within the part of the Baltic Plate studied by the LSU expedition, between jointing and the age of rocks (see Figure 6, b-g). Diagonal type jointing is most important in the stratified formations of the Archean and Lower Proterozoic. The summary diagram of jotnian quartz sandstones of the Petrozavodsk Region shows orthogonal rays. In this case a latitudinal ray is chiefly developed in the Kamennoborskaya Suite, occupying the peripheral position, and the meridional ray is nearly absent. Both rays, particularly the meridional, are well developed in the Shokshinskaya Suite.

The character of the rose diagrams differs sharply from those of sandstones in the Gabbro-diabases that cut across the jotnian sandstones, particularly toward the upper Proterozoic. Then the orientation of the joints in the

Gabbro-diabases of the Petrozavodsk Region and in the Rapakivi granites (γPt_3) of Vborgsk Region is quite close. At the same time the rose diagrams of the joints of the Rapakivi granites of the Vyborgsk and Pitkyarant'sk Regions differ from each other. The separated post Ladozhskoye Microclitic granites (γPt_{1-2}) in Northwestern and Northern Ladozhskoye exhibit similar rose diagrams.

5. Many rectilinear elements of the landscape relief and hydrographic network are related to the strikes of the investigated planetary jointing. These directions, expressed in the landscape, are called *lineaments* (Hobbs and Hill). Sometimes they are traced as parallel straight-lines, intersecting at an angle of about 90° (Zonder).

It may be assumed that the concept of lineament was borne in the Baltic Plate, where Cherul'f (1890) compared the river network of Southern Norway with the jointing system developed therein. Our diagrams of jointing and lineaments are quite similar to those of Cherul'f (Figure 7).

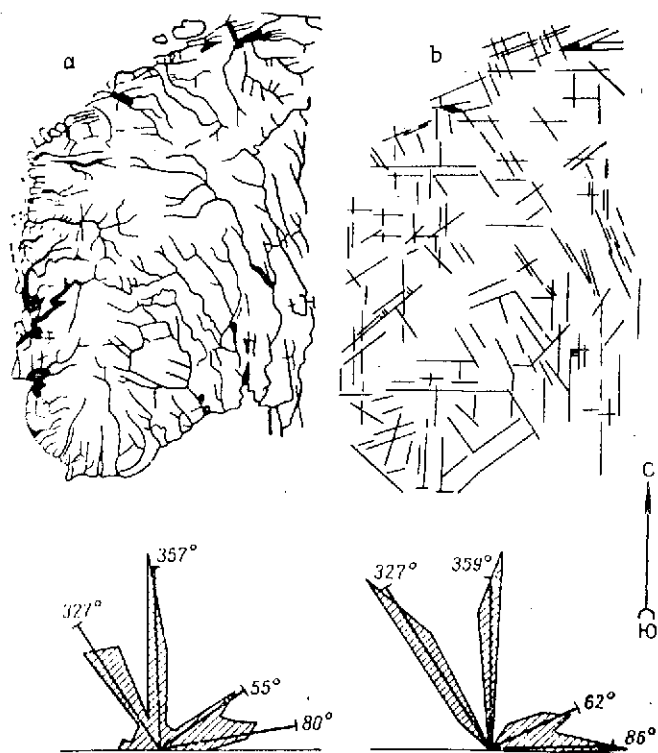


Figure 7. Schematic Maps of River System (a) and Jointing (b) of South Norway (by Cherul'f) and Rose Diagrams Corresponding to Them.

However, the diagrams of 197 the lineaments do not always correspond so well to the jointing diagrams. However, those diagrams of lineaments, constructed on the basis of the maps of various scales, to a large extent, vary greatly from the jointing diagrams of the same regions. Usually only the basic directions exhibit greatest similarity. Even in this case, however, the development of the rays differs. There are apparently many reasons for this. First, the jointing diagrams (for a given region or for a given page of the chart) were constructed on

the basis of the data of individual observation points (quarries, cuts), whereas the diagrams of lineaments were constructed on the basis of aerial data. Second, the compared jointing areas or charts were constructed without consideration of the scale of the initial material, and the charts of lineaments were constructed on the basis of data of maps or aerial photographs of some scale. Incidentally, our experience does not indicate a sharp difference between the directions of rectilinear segments of rivers, measured on maps with the scales 1:25,000, 1:50,000; 1:300,000, 1:1,000,000 and 1:2,500,000. The best results were obtained from aerial photographs and from charting the orientation of ravines and rivers of the "first" order. Individual idiosyncrasies of the mapper, mapping methods and analysis of the linear relief elements, which do not necessarily correspond to jointing, are very important in mapping the rose diagrams of lineaments.

Also important, in addition to rose mapping and vector diagrams of the strikes of lineaments (which are usually combined), are maps of the thickness of lineaments, constructed by various researchers and by various methods. Such a map, constructed for Estonia by student N. Levitan (diploma project) showed that the thickness of lineaments depends on a number of factors: structure, relief, thickness of Quaternary sediments and age of bedrocks.

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The Laboratory of Planetary Jointing is undertaking the known standardization of the collection and processing of data and, considering the experience of Soviet and foreign investigators, is working out a method of analyzing planetary jointing on the basis of direct measurements of joints, and also on the basis of the lineaments. Examination of the procedural problems does not fall within the scope of this article.

6. We have discussed only certain aspects of planetary jointing. Statistical analysis of the jointing of large regions of the Russian platform, and also of the periphery of the Baltic Plate will make it possible to construct the summary rose diagrams of strikes of joints. The summary roses and vector diagrams of large regions of the Platform and Plate are basically similar. The orientation of the diagonal and orthogonal jointing systems corresponds closely to the theoretical network of planetary stresses caused by rotational forces with the contemporary position of the Earth's axis.

Should we conclude that the position of the Earth's axis was unchanged, the continents and parts of them did not drift, and geographic, including climatic zones always strike in certain directions? Should we assume that the jointing scheme is ancient and constant, and that it is transmitted to the sedimentary mantle basically by movements of blocks of the crystalline foundation? We think not.

The rotational forces existed earlier, and continue to exist. Judging by certain differences in the azimuths of strike of rocks of different age, and not only in the mantle, but within the Baltic Plate as well, these forces were not always acting in the same direction. Perhaps joints corresponding to modern plan become more distinct after reorientation of the stress field. They are formed in modern deposits, are reflected in contemporary processes of soil formation, takyridization, in tracks in ice, in karst, in contemporary lavas, and so on.

We assembled some materials on the relation between contemporary processes and jointing. L. S. Brus (on the basis of V. N. Dublyanskiy's data) converted rose diagrams into vector diagrams of the directions of caverns for many karst caverns of Podolia. These directions are also inherent to the planetary jointing network. They are characterized by regular maintenance of strikes in all caverns.

Z. A. Bagrova contends that contemporary planetary stresses are also responsible for the azimuths of strike of the mountain ranges and Mochezhinas in the marshes of Northern USSR, which she investigated (40 and 330°). The same stresses also govern the contemporary position of joints in polygonal soils. During the last ice age planetary stresses governed the strikes of joints formed in glaciers. As the result of accumulation of morainic and fluvioglacial materials in such joints a regularly oriented linear-range relief and intersecting ranges, observed by Z. A. Bagrova in the Arkhangel'sk Region, were formed.

V. P. Miroshnichenko established the law of orientation and relation of joints of various scales, formed in the Takyr of Turkmenia.

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A. F. Grachev measured strictly oriented joints, comprising a columnar section in the Holocene Basalts of the Stanovoye Highlands. He also attributes residual deformations (Kodar lineament) that occurred during earthquakes to two jointing systems, developed in the bedrock of the Kodar Range.

The observations, described above, and conducted by the Laboratory, of contemporary or recent formation of planetary joints and lineaments should be expanded. It is also essential to analyze the cause and effect dependence in the described examples of the relationships between faulting and folding dislocations and the jointing of rocks.

They also mentioned that local platform folds are inherent to the jointing pattern. The examples of meridional zone and Narva-Pskov lineament show, in our opinion, that even larger tectonic zones, bounding enormous blocks of the Earth's crust, are also inherent to the planetary jointing network.

The development of "lineamental tectonics" (Zonder) problems is of tremendous importance. They must be analyzed not only in platform, but also in orogenic regions. Thus, the diagonal Ferganskoye and Chatkal'skoye strikes in Western Tyan'-Shan, formed by recent tectonic activity, require analysis. A whole series of phenomena, requiring special examination, may be contrasted to the latitudinal Alayskoye strike. Among this group of questions are the Caucasian and anti-Caucasian strikes, discussions of "crossed folding," the position of higher points of relief and undulations of joints in parallel ranges and structural forms on the same strike-crossing lines, etc.

In order to solve this series of unexplained questions we must correct factual data on planetary jointing, since without consideration of the lineament network and its joint foundation, we cannot fully judge the tectonic and geomorphologic structure of the Earth as a whole, or structural features of individual regions which we have investigated.

BIBLIOGRAPHY

1. Permyakov, Ye. N., "Tectonic Jointing of Russian Platform," Moscow, p. 53, 1949.

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